Animal Feed Science and Technology 166–167 (2011) 422–429

Contents lists available at ScienceDirect

Animal Feed Science and Technology

journal homepage: www.elsevier.com/locate/anifeedsci

Effects of dietary crude protein and phytase–xylanase supplementation of wheat grain based diets on energy metabolism and enteric methane in growing finishing pigs

Jacob K.A. Atakora[a], Soenke Moehn[a], Jason S. Sands[b,1], Ronald O. Ball[a,*]

[a] Swine Research and Technology Centre, 4-10 Agriculture/Forestry Centre, University of Alberta, Edmonton, AB, Canada T6G 2P5
[b] Danisco UK Ltd., Marlborough, Wiltshire, UK

ARTICLE INFO

Keywords:
Pig
Protein
Phytase
Xylanase
Greenhouse gas
Net energy

ABSTRACT

Dietary crude protein (CP) reduction plus enzymes (*e.g.*, phytase, xylanase) addition to pig diets can decrease nutrient excretion, and may reduce greenhouse gas emissions due to higher nutrient digestibility. Our objective was to study effects of CP reduction and phytase and/or xylanase inclusion in pig diets on enteric CH_4 production, animal performance, dietary metabolizable energy content and nutrient utilization. In a randomized complete block design, 72 gilts (58 ± 0.7 kg, initial body weight) were housed individually and fed for *ad libitum* consumption 6 wheat grain based diets being: high CP control (Con), low CP with added amino acids and phosphate (LP+), low CP without phosphate (LP−), and LP− diets with added phytase (Phy), xylanase (Xyl) or phytase plus xylanase (PX). After 7 d of adaptation, C and N balances were determined over 7 d followed by 24 h measurement of gas exchange. Energy metabolism was assessed using a C/N balance method. Mean daily gain, feed intake and gain:feed was not affected by dietary treatment. Dietary CP reduction tended to increase ($P<0.1$) nutrient, but not energy digestibility. Dietary CP reduction increased N ($P=0.03$) retention and tended ($P=0.07$) to increase C retention, thereby tending ($P=0.097$) to increase dietary net energy content. The P reduction decreased ($P<0.01$) aNDFom and ADFom digestibility, but had no effect on N and C balance or energy metabolism. Phytase and xylanase addition increased ($P<0.02$) aNDFom, ADFom and P digestibility. Other than increasing ($P=0.025$) dietary digestible energy content with phytase addition, phytase and xylanase addition did not affect C, N or energy balance. Xylanase and phytase did not act additively. Dietary CP reduction decreased ($P=0.027$) enteric CH_4 production, but did not affect exhaled CO_2. Dietary CP reduction decreased ($P<0.01$) daily N, C and P excretion. The P reduction and phytase or xylanase addition did not affect exhaled CO_2, enteric CH_4 output or N and C excretion. Phytase and xylanase addition, but not P reduction, decreased ($P<0.01$) P excretion. Results indicate that feeding low CP and P diets with added synthetic amino acids and phytase to finisher pigs optimized utilization of dietary energy, minimized nutrient excretion and lowered enteric CH_4 production by pigs, while maintaining or improving pig performance.

Abbreviations: BW, body weight; CP, crude protein; DE, digestible energy; LP+, low protein diet added phosphate; LP−, low protein without added phosphate diet; ME, metabolizable energy; NE, net energy; Con, control diet; Phy, phytase addition diet; Xyl, xylanase addition diet; PX, diet with phytase and xylanase addition.

* Corresponding author. Tel.: +1 780 492 7151; fax: +1 780 492 4265.
E-mail address: ron.ball@ualberta.ca (R.O. Ball).
[1] Current address: P.O. Box N-9463, Nassau, NP, Bahamas.

0377-8401/$ – see front matter
doi:10.1016/j.anifeedsci.2011.04.030

This article is part of the special issue entitled: Greenhouse Gases in Animal Agriculture – Finding a Balance between Food and Emissions, Guest Edited by T.A. McAllister, Section Guest Editors: K.A. Beauchemin, X. Hao, S. McGinn and Editor for Animal Feed Science and Technology, P.H. Robinson.

1. Introduction

Manipulation of swine diets aims to improve animal performance and reduce nutrient excretion, thereby improving the efficiency and environmental impact of pig production. Reducing dietary crude protein (CP) content with addition of limiting amino acids, and addition of phytase and xylanase, to growing pig diets has shown promise in this regard. For each 10 g/kg reduction in CP content of the diet, urinary N excretion was reduced by 8% (Kerr and Easter, 1995), and animal performance was maintained and dietary net energy (NE) increased (Le Bellego et al., 2001). Xylanase addition to wheat based diets may improve nutrient digestibility and pig growth (Kim et al., 2005). Phytase addition to pig diets reduced P excretion (Oryschak et al., 2002; Adeola et al., 2004), and may improve pig performance (Kim et al., 2005). However, effects of phytase addition on energy metabolism are unclear. Kies et al. (2005) reported a marginal increase in energy retention in pigs fed phytase supplemented diets while Oryschak et al. (2002) reported a reduction in dietary digestible energy (DE) as a result of addition of phytase to a wheat grain based diet, but this was negated by xylanase addition. However, results for phytase/xylanase combinations have been inconsistent, ranging from sub-additive (Kim et al., 2005) to synergistic (Oryschak et al., 2002) on animal performance.

Our aim was to examine effects of dietary CP and P reduction with phytase or xylanase addition, individually or in combination, on performance, nutrient digestibility, energy metabolism, enteric CH_4 production and nutrient excretion in growing finishing pigs fed wheat grain based diets.

2. Materials and methods

The experimental proposal and procedures for care and treatment of the growing finishing gilts were reviewed and approved by the Faculty of Agriculture, Forestry and Home Economics Animal Policy and Welfare Committee of the University of Alberta (Edmonton, AB, Canada).

2.1. Experimental design

Seventy-two Genex F2 (Large White × Landrace) gilts (58 ± 0.7 kg initial body weight (BW)), were fed one of six diets for *ad libitum* consumption in 12 replicates of 6 pigs for a period of 21 d. Pigs were housed individually in 2.1 m × 1.5 m pens and were fed the diets for 7 d followed by a 7 d N balance period and 24 h of indirect calorimetry. The N balance used metabolic crates, and energy metabolism was measured by indirect calorimetry. Pigs were weighed weekly and feed intake was determined daily. Water was available at all times.

2.2. Diet composition

Six diets (Table 1), based on 760–860 g/kg of wheat grain and 100 g/kg wheat middlings, were formulated to be iso-energetic on a metabolizable energy (ME) basis and to achieve equal standardized ileal digestible lysine, methionine, tryptophan and threonine contents. Mineral (except P) and vitamin contents (Table 2) were calculated to meet or exceed (NRC, 1998) Requirements. The control diet (Con) contained protein bound amino acids only, supplied by soybean meal, and contained added dicalcium phosphate to supply P. The other diets were formulated without soybean meal to reduce their CP content, and L-lysine HCl and L-threonine (Degussa, AG, Hanau, Germany) were supplemented to meet NRC requirements. The low CP diet (LP+, low protein adequate P) contained dicalcium phosphate to elevate total P to the NRC recommended level. The low CP diet without supplemental P (LP−, low protein inadequate P) had no dicalcium phosphate added, but Ca was adjusted to the level in LP+ with calcium carbonate. The remaining diets were identical to LP−, except for addition of 500 units of phytase/kg (Phyzyme XP5000, Danisco Animal Nutrition, Marlborough, UK), 4000 units of xylanase/kg (Porzyme 9300, Danisco Animal Nutrition, Marlborough, UK) or 500 units of phytase/kg plus 4000 units of xylanase/kg (PX). One phytase unit is defined as the amount of enzyme required to release 1 mmol of inorganic P/min from a 0.0015 M Na-phytate solution at pH 5.5 and 37 °C (Engelen et al., 2001). One xylanase unit was defined as the activity that releases 1 mol of xylose/min.

2.3. Nitrogen and energy balance

Feces were collected quantitatively and kept frozen until homogenization for freeze drying. Freeze dried samples were ground through a 1 mm mesh and stored in sealed plastic containers until chemical analyses. Daily urine collections were